

WATER DISPERSIBLE, SALT SENSITIVE NONWOVEN MATERIALS

5

FIELD OF THE INVENTION

This invention relates to non-woven materials containing an emulsion binder, and which are water dispersible, yet non-dispersible in aqueous solution containing 0.5 percent or more of an inorganic salt. The non-woven materials can be used to produce non-woven articles, which can be disposed of by flushing down a toilet, and break down into smaller pieces within the wastewater stream.

BACKGROUND OF THE INVENTION

Non-woven fibrous webs have long been used to produce disposable articles, such as garments, wipes, diapers and hygiene articles.

U.S. Patent 5,629,081 discloses pre-moistened, dispersible, biodegradable wet wipes containing a binder containing polyvinyl alcohol, or a polyvinyl alcohol stabilized emulsion.

It is convenient, and environmentally friendly to have a non-woven article, which can be disposed of by flushing down a toilet bowl. U.S. Patent Numbers 5,509,913 and 6,127,593 disclose flushable fibrous articles with solubility related to salt concentration. U.S. Patent Number 5,935,880 discloses dispersible non-woven fabric and a method for making the fabric.

The binder dissolves in water at less than 50 parts per million (ppm) of divalent ions, allowing for the non-woven material to be broken and dispersed in water.

U.S. Patent Applications 09/540,033 and 09/823,318 describe salt sensitive aqueous emulsions which form films that are water-dispersible, yet non-dispersible in aqueous solutions containing 0.5 percent or more of an inorganic salt.

5 There is a need for a non-woven material formed with a salt-sensitive emulsion binder. Surprisingly, a salt-sensitive emulsion binder has been found which can be used to produce non-woven articles, where both the binder and the fibrous web are water-dispersible.

10 **SUMMARY OF THE INVENTION**

The present invention is directed to a non-woven material comprising
a) a web of fibers; and
b) an aqueous emulsion binder comprising a water-dispersible polymer
which is non-dispersible in aqueous solutions containing 0.5 weight
percent or more of an inorganic salt, wherein said water-dispersible
polymer comprises from 1 to 100 percent by weight of a hydrophilic
monomer and from 0 to 99 percent by weight of at least one non-
hydrophilic monomer, wherein a film formed from said polymer has a
Tg of from -40 to +105°C.

20 The present invention is also directed to a non-woven article made of the
novel non-woven material.

DETAILED DESCRIPTION OF THE INVENTION

25 The present invention relates to non-woven materials, formed with
emulsion binders, that are water dispersible, yet non-dispersible in aqueous

solution containing 0.5 percent or more of an inorganic salt.

A non-woven material, as used herein, refers to materials formed from loosely assembled webs of fibers, which are bound together by a polymer.

The binder plays an important role in the properties of the non-woven material

5 such as strength and feel.

Fibers from any source and of any suitable length may be used in the present invention. To aid in dispersion, the fibers preferably will be less than a maximum of 5 cm long and most preferably less than 2 cm long. Fibers include those known in the art including fibers from woody plants such as

10 deciduous and coniferous trees; non-woody plants, such as cotton, flax, esparto grass, milkweed, straw, jute and bagasse; and synthetic fibers, such as polyester, polypropylene, and rayon. Other fiber materials used in the art, and mixtures of any fibers can be used in the present invention. Preferred fibers are those typically used in air-laid non-wovens, especially wood pulp

15 fibers having a length of less than 0.5 cm. Such fibers provide good biodegradable breakdown. Fibers are present in the non-woven material at from 50 to 98 percent by weight, depending on the end use of the non-woven material. For many uses, fibers make up about 70 to 85 percent by weight of the non-woven material.

20 The binder is an emulsion polymer, which is salt sensitive. Salt sensitive emulsion polymers are polymers which are formed by an emulsion polymerization process, and which form films that are dispersible in tap water, yet are non-dispersible in water containing at least 0.5 percent by weight of an inorganic monovalent, divalent, or trivalent salt, or mixtures thereof. The films 25 formed may be continuous or non-continuous.

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The polymer is dispersible, rather than soluble, in water. Dispersible, as used herein, means that in tap water, a film formed from the polymer breaks into small discrete pieces or particles that can be filtered out. These pieces are capable of being separated from the water. While not being bound to a theory, it is believed that the dispersion of the polymer film is related to the fact that a film forms from an emulsion by coalescence of polymer particles, forming weak bonds between particles. In water, some bonds between the particles will break, resulting in clusters of polymer particles. This is different from a solution polymer in which polymer chains mix and entangle during film formation, and this film dissolves into individual polymer chains, which cannot be filtered. Since the polymer contains a high level of hydrophilic monomer(s), when the emulsion dries to a film, the particles are easily dispersed in water. Salt-sensitive emulsion polymers useful in the present invention are described in U.S. Patent Application Number 15 09/823,318, incorporated herein by reference.

The emulsion polymers of the present invention consist of a polymer, which is stabilized by a hydrophilic polymeric colloid. The polymer itself is not salt sensitive. The colloid may or may not be salt sensitive. However, the colloid-stabilized polymer particle is salt sensitive.

20 The polymer colloid contains at least one monomer, and ideally two or more monomers. At least one of the monomers is a hydrophilic monomer.

The hydrophilic monomer may be an acidic monomer containing a carboxylic acid, a dicarboxylic acid, a sulfonic acid, or a phosphonic acid group, or a mixture thereof. Examples of carboxylic acid monomers include, 25 but are not limited to, acrylic acid, methacrylic acid, maleic acid, maleic acid

half esters, maleic anhydride, itaconic acid, and crotonic acid. Preferred carboxylic acids include acrylic acid and methacrylic acid. Sulfonic acid monomers include, but are not limited to styrene sulfonic acid, 2-acrylamido-2-methyl-1-propanesulfonic acid, vinylsulfonic acid, and the salts of these acids. Examples of monomers containing a phosphonic acid group include, but are not limited to styrene phosphonic acid, sodium vinyl phosphonate, vinylphosphoric acid, and $\text{CH}_2=\text{C}(\text{CH}_3)\text{COO}(\text{CH}_2)_n\text{OPO}_3\text{H}$, where n is from 2 to 4. A preferred phosphoric acid monomer is vinyl phosphonic acid. Other hydrophilic monomers include, but are not limited to those containing a hydroxyl group, acrylamides and methacrylamides.

The polymer colloid may also contain at least one other ethylenically unsaturated monomer. Examples of monomers useful in the present invention include, but are not limited to, (meth)acrylates, maleates, (meth)acrylamides, vinyl esters, itaconates, styrenics, unsaturated hydrocarbons, acrylonitrile, nitrogen functional monomers, vinyl esters, alcohol functional monomers.

The hydrophilic monomer(s) is present in the polymer colloid at from 1 to 100 percent by weight. Other ethylenically unsaturated monomers may be present at from 0 to 99 percent by weight. Preferably the hydrophilic monomer is present in the polymer colloid at from 10 to 100 percent and most preferably from 30 to 99.

A graft-linker and/or crosslinker can be incorporated into the polymer colloid. Examples of graft-linkers and/or crosslinkers useful in the present invention include, but are not limited to, diallyl phthalate diallyl amine, allyl methacrylate, ethylene glycol diacrylate, 1,6-hexane diacrylate, methylene

bisacrylamide, divinyl benzene, triallyl amine, triallyl cyanurate, and trimethylolpropane triacrylate.

The polymer colloid may be used to stabilize a latex polymer. The colloid itself can be either salt sensitive or non-salt sensitive. The colloid can 5 either be added to the polymerization process separately, or be formed in situ

Examples of colloids that are salt sensitive include, but are not limited to, poly(acrylic acid), poly(methacrylic acid), and copolymers thereof.

Examples of colloids that are not salt sensitive include, but are not limited to, the salts of poly(2-acrylamido-2-methyl-1-propanesulfonic) acid, the 10 salts of polyphosphonic acid, and polyols.

The colloid is present in the latex polymer at from 0.1 to 100 percent by weight based on polymer solids, more preferably 1 to 75 weight percent , and most preferably from 3-75 weight percent.

The latex polymers useful in the present invention have a Tg of from - 15 40 to +105°C.

The process for producing salt sensitive emulsions of the invention involves the formation of a colloid stabilizer, followed by an emulsion polymerization using said stabilizer by means known in the art. The stabilizer may either be formed in situ, or added separately. A useful process for 20 producing the salt sensitive emulsions is found in U.S. Patent Application 09/540,033, incorporated herein by reference. The emulsion polymerization may be a batch, semi-batch, or continuous process.

One preferred process involves an in situ colloid process in which a polymer seed is polymerized from one or more monomers selected from 25 unsaturated acidic monomers, alkyl(meth)acrylates and vinyl monomers

which are neutralized to between 1 and 100 percent with base to form a stabilizer. Using this stabilizer, monomers are added and polymerized by means known in the art of emulsion polymers.

Another preferred process involves the use of a hydrophilic polymer
5 colloid, as described above as a stabilizer in the synthesis of an ethylene-vinyl acetate copolymer, where the level of ethylene in the copolymer is at least 55 percent by weight of the polymer.

The binder may be formulated with other components known in the art in conventional amounts, prior to being applied to the fiber web. The other

10 components may include, but are not limited to, plasticizers, tackifiers, fillers, humectants, surfactants, salts, fragrances, pigments, titanium dioxide, and encapsulated components. The emulsion binder is present at from 25 to 100 weight percent based on all the components, and preferably at from 50 to 100 percent.

15 Water may also be added to the binder formulation to adjust the solids level and viscosity required for application to the fiber web. Typically the binder formulation is applied at a solids level of from 2 to 60 percent, preferably from 5 to 40 percent and most preferably from 10 to 25 percent.

The non-woven material will generally have an add-on value of from 2 to 50 percent by weight, preferably from 15 to 30 percent by weight.

Non-woven materials of the present invention have a wet tensile strength of at least 100 g/in in an aqueous solution containing three percent or greater of an inorganic salt, preferably sodium chloride. The materials have a wet tensile strength of at least 40 g/in, and preferably at least 60 g/in in tap water. Tap water, as used herein refers to refers to water as sourced to

commercial and residential properties. Tap water generally has a hardness level of from 50 to 300 .

Wet tensile strength as used herein is measured by the TAPPI UM 656 procedure. The non-woven material was soaked in 3 percent sodium 5 chloride solution for 24 hours, and in hard water for 5 minutes.

The non-woven is formed by any process known in the art, such as, but not limited to airlaid, wetlaid, drylaid, carded fiber. Preferably the fiber web formed has a basis weight of from 20 - 200 grams per square meter (gsm).

The binder is applied to the non-woven fibers by means known in the art such

10 as, printing, spraying with and without air, saturation, creping, and foam-application.

In addition to the binder, pre-moistened products produced with the non-woven material of the present invention may also contain a lotion. The lotion contains one or more additives, which include, but are not limited to, sodium 15 chloride solution, preservatives, boric acid, bicarbonates, moisturizers, emollients, surfactants, humectants, alcohols, water, and fragrances. The lotion must contain at least 0.5 percent by weight of an inorganic salt to maintain the integrity of the binder. The lotion is present at up to 500

percentage by weight based on the weight of the non-woven material, and

20 preferably up to 250 percent. The lotion is generally added as a secondary treatment of the non-woven that has been prepared with the salt-sensitive binder and then converted for use. This wet solution treatment can occur just prior to packaging, or after the non-woven has been placed Wet-use products have a stable wet strength of measurable tensile value and integrity, yet 25 disperse when placed in tap water, allowing the product to be flushed in sewer

or septic systems without blockage. In water, dispersion of the non-woven begins immediately. The rate of dispersion can be tailored for different applications.

- Dry products formed with the non-woven material of the present
- 5 invention may also contain up to 50 percent by weight, and preferably up to 30 percent by weight, of other ingredient including, but not limited to, perfumes, plasticizers, colorants, antifoams, bactericides, bacteriostats, thickeners, and fillers.

- Non-woven materials of the present invention are used to form a variety
- 10 of both dry and moist finished products. These products include, but are not limited to wet products such as personal cleansing wipes for personal hygiene uses such as bathroom, facial, and make-up removal; and dry products such as diaper and adult incontinence top sheets, back sheets, acquisition layers and absorbent core; feminine hygiene products; industrial towels/wipes for
- 15 aqueous and solvent use; surgical gowns and towels.

One key attribute of the non-woven materials of the present invention is their ability to retain insult durability in use, then disperse during flushing in water.

- 20 The following examples are presented to further illustrate and explain the present invention and should not be taken as limiting in any regard.

EXAMPLE 1

- A 60 gsm air-laid cellulosic fiber (Weyerhauser NB416) was pad saturated
- 25 with a 12% solids formulation of salt-sensitive emulsion polymer of

MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 15%. The wet web was drum dried at 210°F. The web was subsequently heated for 5 minutes at 266°F in a forced-air oven. After conditioning, the web was tested for its tensile strength in 3% NaCl and then in tap water for 5 minutes after soaking in the 3% NaCl for 4 days, 10 days, and 22 days. Tensiles were pulled using the TAPPI UM 656 procedure. Following is the data that was generated.

Age	Tensile, g/in	Tensile, g/in
	3% NaCl	3% NaCl → 5 min soak in tap water
4 days	135	44
10 days	101	45
22 days	100	45

EXAMPLE 2

10 Whatman #4 Chromatography Paper was pad saturated with a 15% solids formulation of salt-sensitive emulsion polymer of MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 15%. The wet web was drum dried at 210°F. The web was subsequently heated for 5 minutes at 266°F. After conditioning, the web was tested for its tensile strength in DI water, and
15 1%, 3%, and 5% NaCl solutions. A non-crosslinking VA/BA polymer was used as a reference. Tensile strength was measured using the TAPPI UM 656 procedure. Following is the data that was generated to demonstrate the effect of ionic strength on tensile strength of the non-woven.

	Tensiles, g/in			
	0%	1% NaCl	3% NaCl	5% NaCl
BA/VA	196	218	223	260
MAA/AMPS/M MA/BA	80	158	323	766

EXAMPLE 3

- 5 A 60 gsm air-laid cellulosic fiber (Weyerhauser NB416) was pad saturated with a 15% solids formulation of surfactant stabilized salt-sensitive emulsion polymer of MAA/MMA/BA in a weight ratio of 60/15/25 to a dry add-on of 20%. The wet web was drum dried at 210°F. The web was subsequently heated for
- 10 5 minutes at 266°F. After conditioning, the web was tested for its tensile strength in 3% NaCl, 3% CaCl₂, and 3% MgCl₂. The web was also tested for its strength in tap water. Tensiles were pulled using the TAPPI UM 656 procedure. Following is the data that was generated to demonstrate the effect of different cations on tensile strength of the non-woven:

	Tensile, g/in		
	3% NaCl	3% CaCl ₂	3% MgCl ₂
	75	240	194
Tap Water	20	88	42

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EXAMPLE 4

- 20 A 60 gsm air-laid cellulosic fiber (Weyerhauser NB416) was pad saturated with a 16% solids formulation of surfactant stabilized salt-sensitive emulsion polymer of MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 20%. The wet web was drum dried at 210°F. The web was subsequently heated for 5 minutes at 300°F. After conditioning, the web was
- 25 tested for its tensile strength in 3% and 5% NaCl and then in hard water (625

ppm calcium carbonate) for 5 minutes after soaking in the 5% NaCl for 7 days. The web was also tested in for its strength in de-ionized water. Tensiles were pulled using the TAPPI UM 656 procedure. Following is the data that was generated:

Tensile, g/in				
3% NaCl	3% NaCl→ Hard Water	5% NaCl	5% NaCl→ Hard Water	DI Water
221	224	198	118	223

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EXAMPLE 5

A 60 gsm air-laid cellulosic fiber (Weyerhauser NB416) was pad saturated with a 16% solids formulation of surfactant stabilized salt-sensitive emulsion polymer of MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 20%. The wet web was drum dried at 210°F. The web was subsequently heated for 2 minutes at 250°F. After conditioning, the web was tested for its tensile strength in 3% and 5% NaCl and then in hard water (625 ppm calcium carbonate) for 5 minutes after soaking in the 5% NaCl for 7 days. The web was also tested in for its strength in de-ionized water. Tensiles were pulled using the TAPPI UM 656 procedure. Following is the data that was generated:

Tensile, g/in				
3% NaCl	3% NaCl→ Hard Water	5% NaCl	5% NaCl→ Hard Water	DI Water
168	127	174	145	124

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EXAMPLE 6

A 60 gsm air-laid cellulosic fiber (Weyerhauser NB416) was pad saturated with a 16% solids formulation of surfactant stabilized salt-sensitive emulsion

polymer of MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 20%. The wet web was drum dried at 210°F. The web was subsequently heated for 2 minutes at 250°F. After conditioning, the web was tested for its tensile strength in 3% and 5% NaCl and then in hard water (625 ppm calcium carbonate) for 5 minutes after soaking in the 5% NaCl for 7 days. The web was also tested in for its strength in de-ionized water. Tensiles were pulled using the TAPPI UM 656 procedure. Following is the data that was generated:

Tensile, g/in				
3% NaCl	3% NaCl→ Hard Water	5% NaCl	5% NaCl→ Hard Water	DI Water
221	224	198	118	223

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EXAMPLE 7

A 60 gsm air-laid cellulosic fiber (Weyerhaeuser NB416) was pad saturated with a 16% solids formulation of salt-sensitive emulsion polymer of 15 MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 20%. The wet web was drum dried at 210°F. The web was subsequently heated for 2 minutes at 250°F. After conditioning, the web was tested for its tensile strength in 3% and 5% NaCl and then in hard water (625 ppm calcium carbonate) for 5 minutes after soaking in the 5% NaCl for 7 days. The web 20 was also tested in for its strength in de-ionized water. Tensiles were pulled using the TAPPI UM 656 procedure. Following is the data that was generated:

Tensile, g/in				
3% NaCl	3% NaCl→ Hard Water	5% NaCl	5% NaCl→ Hard Water	DI Water
148	113	259	171	9

EXAMPLE 8

A 60 gsm air-laid cellulosic fiber (Weyerhauser NB416) was pad saturated
 5 with a 16% solids formulation of salt-sensitive emulsion polymer of
 MAA/AMPS/MMA/BA in a weight ratio of 57/5/14/24 to a dry add-on of 20%.
 The wet web was drum dried at 210°F. The web was subsequently heated for
 5 minutes at 300°F. After conditioning, the web was tested for its tensile
 strength in 3% and 5% NaCl and then in hard water (625 ppm calcium
 10 carbonate) for 5 minutes after soaking in the 5% NaCl for 7 days. The web
 was also tested in for its strength in de-ionized water. Tensiles were pulled
 using the TAPPI UM 656 procedure. Following is the data that was
 generated:

Tensile, gf				
3% NaCl	3% NaCl→ Hard Water	5% NaCl	5% NaCl→ Hard Water	DI Water
356	239	444	295	97